and, second, the co-existence of local-area and wide-area systems in the same spectrum is not inimical to high-quality wide-area service. The comments submitted in response to the *NPRM* support these views.

A. The Commission Should Make the Entire Band Available to Wide-Area Systems Because the Throughput Capacity of Wide-Area Systems Is Exponentially Related to Bandwidth

Pinpoint demonstrated in its comments that the capacity of a wide-area operation is related to up to the cube in the increase in bandwidth. Accordingly, an increase in bandwidth from 4 MHz to 16 MHz, for example, would mean over a fifty-fold increase in capacity.

The comments of PacTel support this finding, despite the fact that they erroneously suggest that the relationship between the changes in bandwidth and throughput is exponential only to a factor of two, and not three.[114] PacTel's result understates the beneficial effects of increased bandwidth because, as Pinpoint noted in its opening comments, PacTel used the derivation for the gaussian-white-noise case only, whereas in the 902-928 MHz band it may be limited by narrowband noise.[115] The fact remains, however, that an exponential increase in capacity only underscores the wisdom in sharing through time-division, as that is the only method by which multiple firms will be able to exploit the exponential increase associated with larger

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[114] PacTel Comments at 23. MobileVision likewise recognizes to increase in capacity as bandwidth increases. MobileVision, tech. app. at 31.

[115] Pinpoint Technical Appendix.

bandwidths.[116] Moreover, such capacity is needed to facilitate sharing consistently with the demands for high capacity applications, such as those associated with IVHS. Accordingly, the Commission should make the entire 26 MHz of the band at issue in this proceeding available for licensing to wide-area systems on a shared basis.

B. Sharing Between Wide-Area and Local-Area AVM Systems Is Consistent with the Provision of High-Quality Wide-Area Service

Pinpoint, alone among the wide-area AVM technology developers filing comments in this proceeding, acknowledges the ability of wide-area systems to share the band with local-area systems. Through the judicious placement of base station sites, the use of higher powers by both bases and mobile, the retransmission of position-fixing pulses by mobiles, and filtering of local-area signals, the adverse effects of co-channel local-area systems can be minimized.[117]

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[116] Southwestern Bell proposes that the FCC create four 4 MHz sub-allocations for exclusive wide-area licensing. While this frequency division multiple-access approach reflects an appreciation that the public interest is best served by more open entry and greater competition, it will result in markedly inferior choice, in terms of throughput capacity and less competition, than TDMA sharing over a larger bandwidth. Ironically, PacTel and MobileVision, both of which require only 4 MHz of spectrum to deploy their systems, question the sufficiency of 4 MHz assignments. *See* PacTel Comments at 23; MobileVision Comments at 36. While they are correct, neither of them has taken advantage of the bandwidths which each has been assigned.

[117] As Exhibit C to its comments, Pinpoint provided an analysis of how the placement of base station transmitters relative to a local-area station, and their power levels, affected the size of the area surrounding a local area where there was a significant potential for harmful interference. As a

PacTel, MobileVision, and Southwestern Bell assert the inability of wide-area and local-area systems to share. By and large, these commenters take comfort principally in the *NPRM*'s preliminary observations that such sharing may be difficult. However, their comments themselves do not substantiate the *NPRM*'s statements; rather they identify the existence of the problem and, at bottom, assume the absence of solutions.

PacTel, in fact, describes many of the same solutions as Pinpoint, but fails to acknowledge the fact.[118] Specifically, the commissioned study attached to PacTel's comments, prepared by Dr. Pickholtz, poses the scenario of how an established wide-area system might act to counter the introduction of a second wide-area system.[119] Pinpoint notes, as PacTel does not, that these steps could even more effectively be taken by a wide-area system in reponse to a local-area system located in the same market.[120]

PacTel notes that a second wide-area system is likely to react to these steps with identical counter-measures. While this may be true, Pinpoint submits that a local-area system, because it is much less susceptible to interference than wide-area technologies, would not respond in kind. Moreover, because wide-area systems would be operating

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[118] Actually, PacTel makes one footnote reference on the applicability of its discussion to wide-area system sharing to the co-existence of wide-area and local-area systems, which in PacTel's parlance it calls "narrowband." See PacTel Comments at 28 n.32 (Pickholtz study applies to narrowband systems as well as wide-area HML systems).

[119] Pickholtz at 35-43.

[120] More realistically, the wide-area system would undertake some of these steps, such as increased power and wider bandwidth, even before being faced with a local-area system in the market.

on a TDMA basis, under Pinpoint's plan, these measures would not increase the interference potential to other wide-area systems. Thus, because there would be no escalation, the steps taken by a wide-area system would be permanently effective.

Accordingly, PacTel has noted the following measures as being effective in responding to a local-area system in the same market:

* Higher power pulses;[121]
* Additional bandwidth;[122]
* Filtering;[123]
* Directional antennas;[124] and
* Additional base stations.[125]

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[121] Pickholtz at 35. Because Pinpoint poses a wider bandwidth, the pulse duration could be significantly short so as to make any per mobile unit costs increases marginal. Moreover, Pinpoint notes that PacTel's claims about the cost of mobile unit replacement are not material since PacTel has operations in only a few cities, in none of which, Pinpoint understands, is PacTel sharing frequencies with any local-area systems. Thus, replacement could occur gradually and over a reasonable transition period.

[122] *Id.* at 37-38. Under Pinpoint's band plan, unlike that supported by PacTel, such bandwidth would be available, overcoming one of PacTel's principal objections, that the bandwidth is unavailable. Professor Pickholtz's discussions about the amount of bandwidth needed to make a material difference assumes interference from a co-channel wideband system base station, not a more benign low power local-area base station.

[123] *Id.* at 39. Of course, PacTel had already noted that narrowband systems could be effectively filtered.

[124] *Id.* at 39-40.

[125] *Id.* at 42. In possibly silent acknowledgement that the addition of one or two additional base stations near a low-power local-area system could be particularly effective, as Pinpoint demonstrated in Appendix C to its comments, Professor Pickholtz notes that *"[t]he least harmful type of interference involves a low-power interfering transmission from a transmitter on the ground and placed close to a pulse-ranging system's base station."* *Id.* at 11. Accordingly, it should be particularly effective to "bring the base station" to the local-area system.

These methods discussed by PacTel, particularly in combination, provide an entire battery of permanent, effective methods that could be used to counter potential interference from local-area systems.

In a study attached to its comments, PacTel illustrated the feasibility of sharing among wide-area and local-area AVM systems from actual field results.[126] Ostensibly designed to show that uncoordinated simultaneous co-channel operation of two wideband systems would result in intolerable interference, the PacTel study actually shows how power management and the judicious placement of receive sites can facilitate the use of the same band by wide-area systems and local-area systems.[127]

In conducting this experiment, PacTel established a wideband interferer atop its 100 foot high building near the center of its Dallas-Fort Worth coverage area. The interferer was to simulate a wideband wide-area system forward link. It was centered at 908 MHz, the same frequency employed by PacTel for the center of its current 4 MHz wide system. The interferer operated with a maximum ERP of 38.9 watts.[128]

PacTel then determined how many sites out of a maximum possible number of "14 to 16" could receive the signal of its mobile unit. The tests were carried out with

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[126] PacTel Comments, app. 2 (Theoretical and Field Performance of Radiolocation Systems, June 25, 1993).

[127] Contrary to the straw man argument against which PacTel has devoted substantial resources, Pinpoint has not proposed simultaneous uncoordinated co-channel sharing. Instead, Pinpoint has advocated time division multiple access as a means for sharing the spectrum among wide-area licenses. Local area systems would not be operated on a TDMA basis with wide-area systems, but would be restricted to substantially less power than wide area systems.

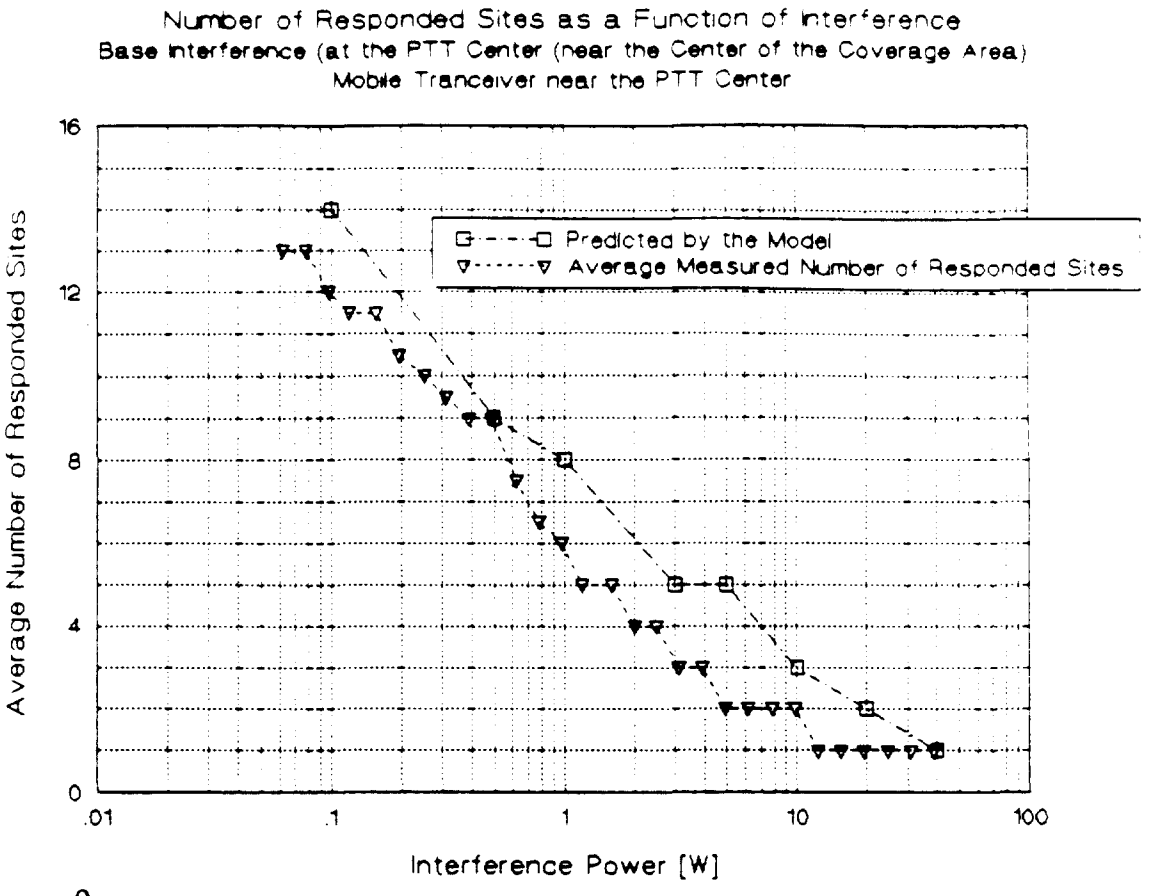

Figure 9

Figure 9 plots the average number of sites detecting a pulse as a function of the interference power. It also plots the model's prediction of the number of sites that would detect a pulse. The predicted and measured performance agree closely. The model predictions tend to be about 3 dB more optimistic than the actual field measurements.

the interferer operating at effective radiated powers ranging from 62 mW to 38.9 watts. The average number of receive sites capable of detecting the presence of a pulse from the mobile were then tabulated and presented in Table 2 of the report and displayed graphically in Figure 9 of PacTel's Appendix 2. Figure 9 is reproduced below.

The data summarized above show that only five sites could receive the PacTel mobile's wideband pulse when the interferer was operating at 1 watt. According to PacTel, at least four sites must receive the signal "to guarantee an unambiguous location estimate. In practice, an operating pulse-ranging system would probably use more than four receive sites to improve the quality of the location estimates and to improve reliability."[129] Significantly, Pinpoint has proposed an alternative under which there would be quiet sub-bands at 906 - 910 MHz and 920 - 924 MHz to accommodate wide-area systems, such as PacTel's, that are using only 4 MHz.[130] At 907 - 909 and at 921 - 923 MHz, local area systems would be restricted to an ERP of 50 milliwatts and height of no more than approximately 30 feet above ground.[131]

PacTel's Figure 9 shows no apparent interference at 50 milliwatts on a theoretical basis and that empirically, 12 to 14 sites were receiving the signal when the interferer operated at 62 milliwatts. Elsewhere in the sub-band, tag readers would operate at no more than 200 milliwatts ERP under Pinpoint's proposal. When the

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[129] Pickholz at 6.

[130] *See* app. A.

compatible with those wide-area systems that are engineered to operate in a relatively noisy shared band.[133]

MobileVision, too, presents evidence that sharing is feasible. For example, MobileVision notes the use of retransmissions by mobile units. Contrary to MobileVision's suggestion, such a feature need not reduce system capability appreciably if other methods, as suggested by Pinpoint and PacTel, are taken to minimize the size of "black out" areas that would trigger the need for retransmissions.[134]

At bottom, therefore, co-existence based upon mutual cooperation and effort by wide-area and local-area systems is feasible. Because the public interest would benefit from the widest possible bandwidth being available for wide-area systems, the FCC should allocate the 902-928 MHz band for licensing on a sharing basis to both wide-area and local-area systems.

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[133] Pinpoint has conducted measurements on the local-area system that uses AMTECH technology to collect tolls on the Dallas North Tollway. The tag readers there were operating with about 7 watts ERP employing very high gain directional antennas canted downward toward the tags on cars. At about one-half mile away, however, the signals from the tag readers were sufficiently scattered by cars and the road so as to be consistent with a transmitted power of less than about a watt. Thus, the gain of the directional antenna was not adding to the interference at this distance.

[134] Pinpoint questions MobileVision's commitment to install a system architecture consistent with robust operation. As an illustration, MobileVision suggests that a typical distance between mobile units

V. WIND PROFILERS SHOULD NOT BE ALLOWED TO DEVELOP "IN PARALLEL" WITH AVM AND LMS

In this proceeding, the Commission has proposed to allocate the 902-928 MHz band to AVM. By doing so, the FCC will usher in a new age in vehicle location services and mobile resources management. One commenter, Radian Corporation ("Radian") seeking to expand the scope of this proceeding -- and to overcome its frustrations in another docket -- requests the FCC to jeopardize the future growth and enhancement, not to mention the important public benefits, of AVM.[135] Radian asks the FCC in this proceeding to allow AVM and commercial wind profiling to proceed in the 902-928 MHz band side-by-side.[136]

The Commission should not allow commercial wind-profiler systems to delay or otherwise hinder the full deployment of AVM systems and technologies. As developed fully in Docket 93-59, Radian's contemplated operations would present a serious interference threat to many AVM systems, particularly broadband wide-area operations.[137] One of the chief and consistent complaints in that proceeding was that

Radian failed to provide sufficient information to permit a full analysis of the interference potential wind profiler systems pose. At the same time, the commenters noted that the limited data proffered by Radian made clear the danger.[138]

While Radian supplied some additional description of its proposed wind profiler radar systems in its reply comments in Docket 93-59, Pinpoint notes that the potential for wind profilers to wreak havoc has merely been confirmed. Namely, the exceptionally high antenna gain of Radian's 500 watt, high-frequency-pulse[139] transmitters will produce approximately 15 watts of energy in the horizontal direction (up to a 5° elevation), even with fences providing -45 dB suppression of sidelobes relative to peak.[140] Thus, it is likely that wind profiler operations, even with minimal spreading through the use of longer pulses, would seriously limit the ability of wide-area AVM systems to spread over large parts of the 902-928 MHz band, with significant costs in terms of lower capacity.[141]

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[138] *See, e.g.*, Pinpoint Wind Profiler Comments at 4; Pactel Wind Profiler Comments at 2; *see also* Comments of AMTECH, RM-8092 (June 15, 1993).

[139] Radian indicates a pulse repetition rate of 100 to 50,000 times per second.

[140] Reply Comments of Radian Corp., ET Docket No. 93-59, exh. A. Of course, this level of suppression assumes the fences will operate up to specification, not a foregone in a service to be

Given the important public advantages flowing from AVM systems, both wide-area and local-area, it is important that sufficient spectrum be allocated to permit achievement of those benefits. As the Senate Appropriations Committee recently stated, it is important that the FCC adopt

> [a]utomatic vehicle monitoring and automatic vehicle identification rules that, consistent with the policies and goals of the Intelligent Vehicle Highway Systems Act of 1991, would promote the development and implementation

environmental air quality studies. Weather-forecasting involves primarily high-altitude applications which are better performed at 449 MHz,[144] which the FCC has already proposed to allocate to wind profilers.[145] Concerning the measurement of air quality, federal environmental agencies can use the governmental radiolocation allocation at 915 MHz, and there is no showing of demand for this use on a non-governmental basis.[146]

Further, Pinpoint notes that the incremental environmental benefit of adding another method of air-quality measurement pales besides the potential benefits of high-capacity IVHS. Therefore, the FCC should not allow Radian's proposal to slow the implementation of AVM systems throughout the 902-928 MHz band. Rather, the Commission should continue to study the compatibility of wind profiler systems in ET Docket No. 93-59, and determine what action, if any, is appropriate in response to Radian's request only after final AVM rules are adopted.

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[144] Comments of the National Oceanic and Atmospheric Admin., ET Docket No. 93-59 at 6 (filed June 15, 1993).

[145] *Spectrum for Wind Profiler Radar Systems*, 8 F.C.C. Rcd 2546, 2546 (1993) (Notice of Proposed Rule Making and Notice of Inquiry).

[146] Pinpoint notes that there is a significant amount of radio spectrum in the 1200 MHz band allocated to radiolocation which might be suitable for air quality monitoring. 47 C.F.R. § 2.106. *See also* Comments of the American Meteorological Society, ET Docket No. 93-59 (July 15, 1993) (900-1300 MHz considered a single band for wind profiling operations).

VI. THE STATUS OF AND REGULATIONS GOVERNING PART 15 AND AMATEUR OPERATIONS SHOULD NOT CHANGE

Two groups of commenters representing the manufacturers of devices regulated by Part 15 of the FCC's rules -- and the related user community -- and amateur radio operators question the need for opening the entire 902-928 MHz band for AVM purposes. Pinpoint has demonstrated in its comments, and in the above discussion, the numerous important public interest benefits flowing from making the entire 26 MHz band available for AVM systems. Chief among them is the fact that maximizing the available bandwidth prepares the way genuine competition in the provision of high-capacity wide-area AVM services and deployment of IVHS. Without such an expansion in the spectrum, it is a virtual certainty that the throughput necessary to achieve mature intelligent vehicle highway systems can be achieved. As the 902-928 MHz band is the ideal home for wide-area IVHS, regulations foreclosing adequate spectrum will squander an ideal, even unique, opportunity and set back the prospects for achieving important national transportation policies for many years.

A review of the record reveals that the calls by the amateur and Part 15 communities for the *status quo ante* or a more limited expansion of AVM into the 902-928 MHz band than proposed in the *NPRM* are borne of the fear that the less robust systems of some AVM operators, such as PacTel and MobileVision, will not be able to tolerate these secondary operations. Pinpoint recognizes their concern, but notes that under the AVM sharing scheme Pinpoint proposed in its comments,

wide-area systems will need to be robust enough to tolerate co-channel interference from co-primary local-area operations. Thus, wide-area system developers will need to engineer-in a robustness that should also permit them to tolerate the use of Part 15 devices.

As explained in the attached Technical Appendix, the Pinpoint system possesses this requisite degree of robustness. Conversely, Pinpoint's contemplated operations will not preclude use of Part 15 devices. Pinpoint does not believe it will cause undue interference to secondary amateur operations.[147]

In sum, the Commission need not and should not consider restricting the current access of users that are secondary to AVM to the 902-928 MHz band. Similarly, the FCC need not modify the technical regulations under which Part 15 devices and the amateur radio community operate.

VII. CONCLUSION

For the foregoing reasons, the Commission should allocate the entire 902-928 MHz band to AVM systems. Further, the final rules should provide for shared use of the whole band by all AVM system types. Finally, the FCC should expeditiously open

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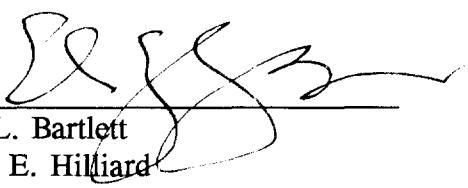
[147] *See* Technical Appendix.

filing windows for wide-area AVM system applications in order to usher in the competitive provision of high-capacity IVHS and other AVM/LMS services.

Respectfully submitted,

PINPOINT COMMUNICATIONS, INC.



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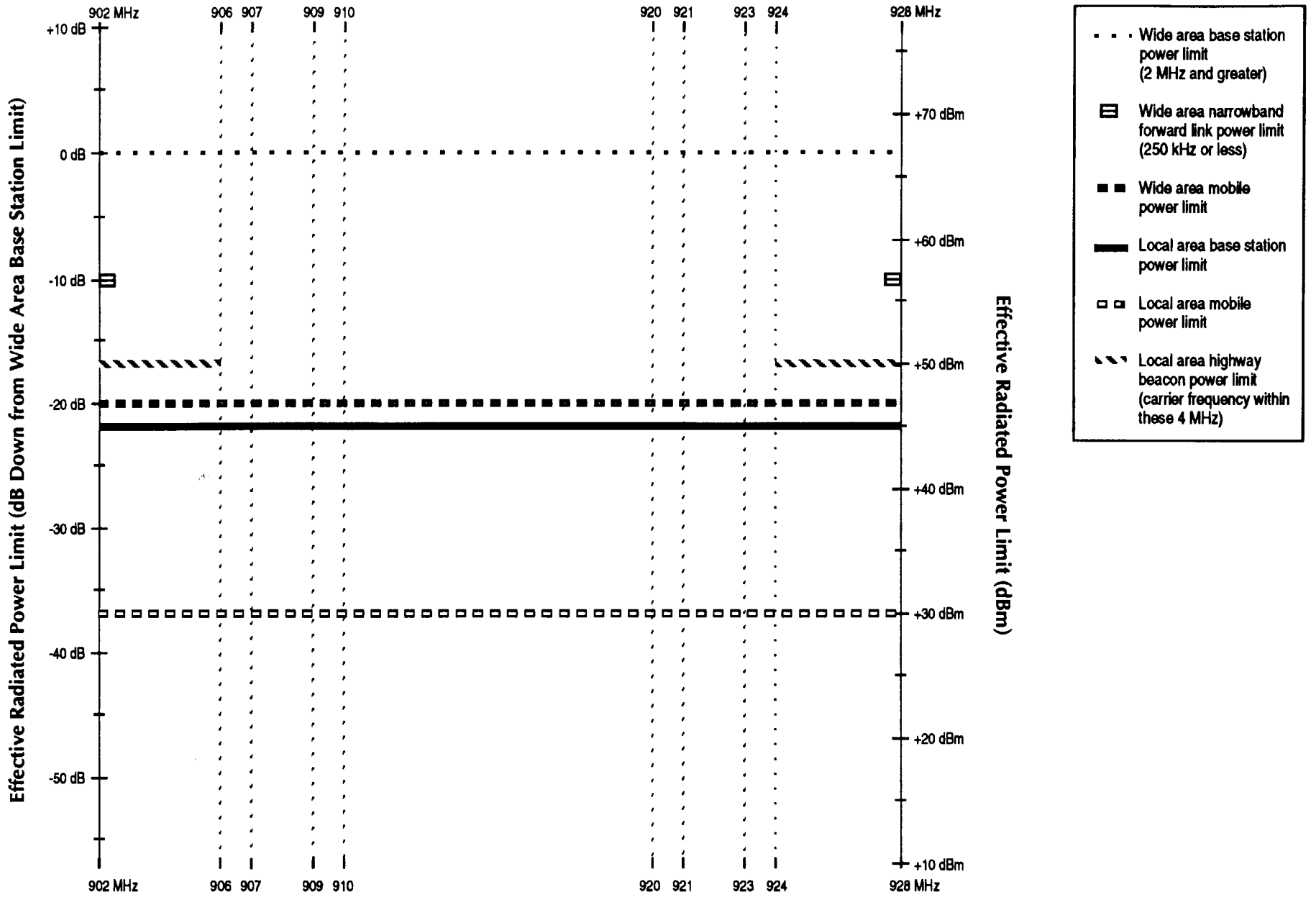
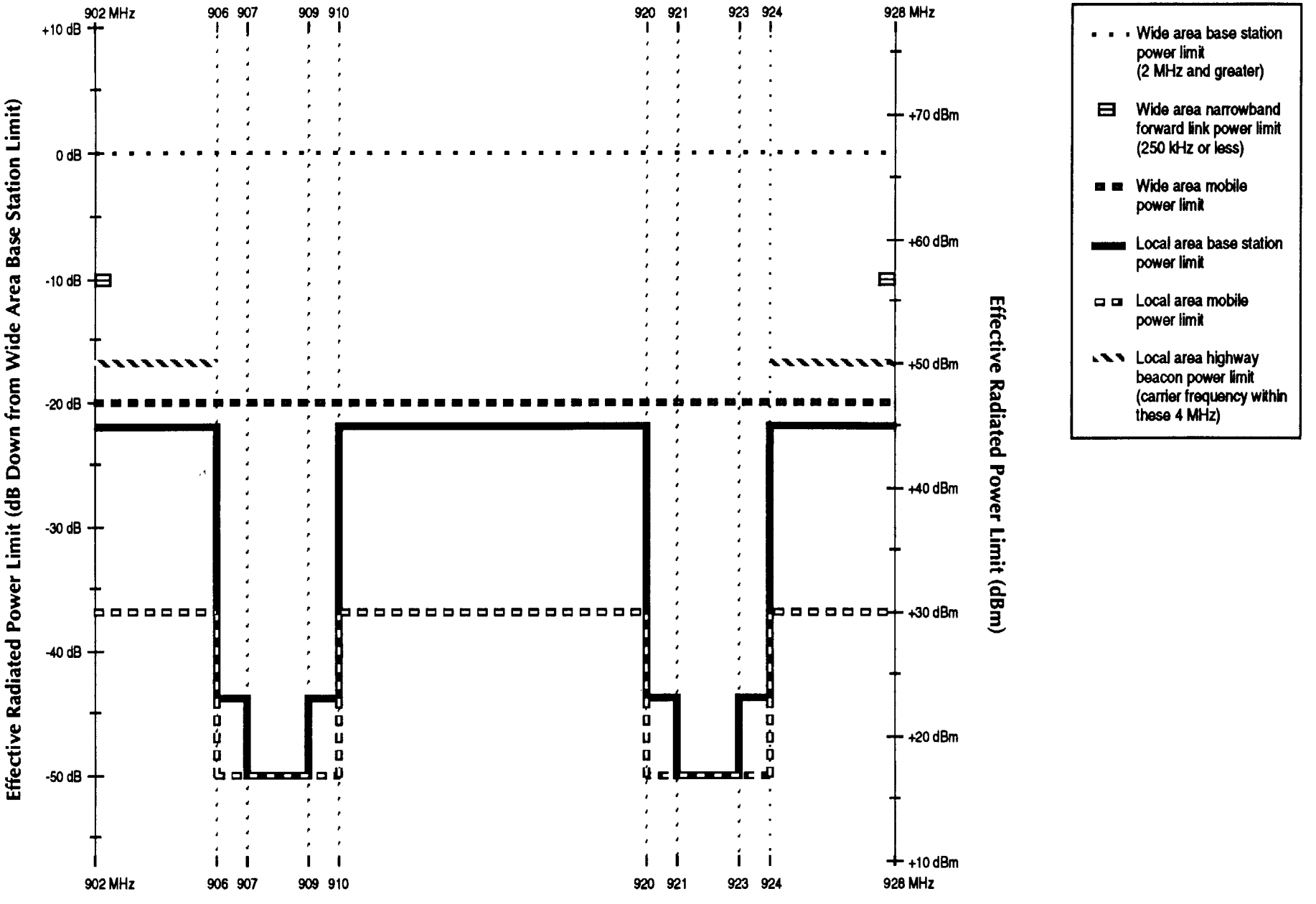
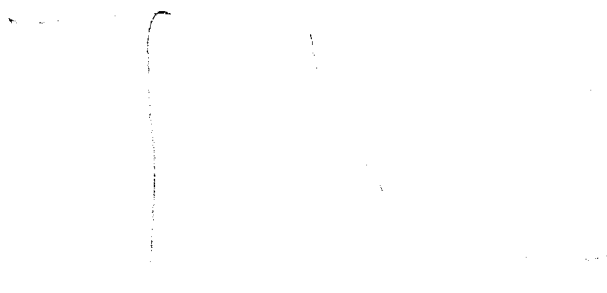


Proposed Power Limits for LMS Systems in the 902-928 MHz Band (Preferred Plan)



Proposed Power Limits for LMS Systems in the 902-928 MHz Band (Alternative Plan)



TECHNICAL APPENDIX

Response to Comments Filed in PR Docket No. 93-61 Concerning the Adoption of Final Regulations Governing Automatic Vehicle Monitoring

Prepared by Louis H.M. Jandrell
Vice President of Design and Development
Pinpoint Communications, Inc.

Pinpoint Communications, Inc. ("Pinpoint"), an innovator in automatic vehicle monitoring ("AVM") technology, stands out among wide-area AVM technology proponents filing comments in this proceeding in several respects: Pinpoint is the only developer of a system, ARRAY™, with sufficient capacity to serve multiple intelligent-vehicle highway systems ("IVHS") applications in large metropolitan areas. Pinpoint is the only developer to describe a realistic method for sharing among co-channel wide-area systems. Pinpoint is also the only wide-area system proponent to propose a well-designed wide-area AVM systems that will successfully co-exist with local area systems and other users of the 902-928 MHz band in the same spectrum.

It is with these distinctions in mind that the following responses are offered on the initial comments filed in the Commission's PR Docket No. 93-61:

A. Why ARRAY™ is the Only Current Technology Capable of Handling the Radiolocation and Messaging Needs of IVHS

The most current statistical vehicular traffic information

by any current location and/or messaging system or combination of the two. Data put together by a vehicular technologist working in the IVHS area are summarized in the attached tables.[1] They are based on composite demographic data from five cities of approximately two million in population.

The actual city-specific demographic data are summarized in Table 1, and the projected vehicular traffic data, in Table 2. Pinpoint has used this as the basis for making estimates of both the radiolocation and message traffic requirements of early (*i.e.* currently described) IVHS traffic monitoring and traveler information programs. The projections do not address the additional capacity that may be needed for more mature programs such as individual vehicle traffic control (for such purposes as optimal traffic routing). Tables 3 and 4 summarize the model and network capacity estimates required for traffic monitoring and traveler information systems, respectively, based upon the information provided in Tables 1 and 2.

Table 3 shows that only modest market penetration (2.5% to 5% of vehicle population) is required in order for IVHS applications to yield significant returns to the IVHS system users in terms of real time information on traffic conditions.

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[1] The data are taken from a summary of a report prepared by the Mitre Corporation for the Federal Highway Administration entitled "Communication, Storage and Processing Load Requirements of Alternative IVHS Architectures," by Cheslow, Hatcher and Hsin, presented at the IVHS America meeting in April 1992, and made available recently at the TransTech Conference, Seattle, July, 1993.

The results also show that the radiolocation and messaging capacities required are much larger than the total capacities of any currently deployed radiolocation or radio-data messaging systems. For example, estimates based on this latest data from the TransTech Conference suggest that on a per-million population basis, during the typically bi-daily 3-hour traffic peaks (the rush hours), about 170 position fixes per second or about 620,000 position fixes per hour would be required to get a high quality estimate of traffic conditions. (Assumed here is the need for an average three location and velocity estimates per IVHS-active vehicle mile.) This translates to about a thousand position fixes per second across the whole of the Washington-Baltimore Metroplex.

The addition of traveler-information functions to an AVM system make the total capacity requirements significantly larger. There are also other uses. Table 4 reflects estimates that include the IVHS data requirements of public transit (busses) and safety (police & ambulance/rescue), commercial, government and business fleets and individual automobile drivers. The estimates do not include data-base access by public safety operations.

With only moderate penetration of IVHS capability into this part of the market (3% of individual vehicle-owners, 10% of all fleet operators, and most of the safety and transit operators), Table 4 shows that the data requirements of traveler information systems are significant, roughly equaling that required by IVHS

traffic monitoring. With modest market penetration, therefore, the capacity required to meet the demand for radiolocation and messaging is large. The approximately equivalent data capacity would be about 70,000 bits per second, delivered in short messages.

Because the ARRAY™ network utilizes the same broad-band signal to carry both the data message and the radiolocation function, it achieves significant gains in system capacity over other approaches. A particularly significant advantage is the support of a high data rate. Other techniques contributing to ARRAY™'s high throughput include its contemplated use of a very wide bandwidth (up to 26 MHz as explained in Pinpoint's earlier submissions in this proceeding) and frequency reuse in multiple coordinated base-station clusters in a given city.[2]

Other vehicle location approaches, for example, those which segregate the position fixing and communications elements, require twice as much system capacity to achieve the same throughout.[3] For example, GPS might be the vehicle location

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[2] ARRAY™ forms a virtual, rather than physical, cluster around each ARRAY-equipped vehicle. Central coordination allow co-existence of multiple clusters in a single metroplex.

[3] Vehicle location is never performed alone, but as a part of a larger, typically integrated solution, which usually involves some communications components, as required for management, control or support functions of the vehicle being located. In contrast, single-function system, (e.g., vehicle location alone) are sub-optimal solutions, because other, often overlapping, systems are then needed to fill out the full mobile resource solution requirements.

technology and a Mobitex or ARDIS system might be used for carrying the vehicle locations data and other messaging. The data capacity requirement to achieve Pinpoint's level of performance would be nearly twice as large, because about a half of the capacity would be needed for radiolocation only. Transmitting the location solution from the vehicle would require approximately the same amount.

Other, currently deployed, "stand alone" systems are clearly deficient for IVHS. A technology like Lo-Jack, a direction-finding tracking technology designed for stolen vehicle recovery (requiring a specially equipped tracking vehicle to physically pursue a beacon transmitter on the vehicle being located), is a low-volume system wholly unsuited to meet the multi-faceted requirements of IVHS, although it apparently works well for its designed purpose.

Hyperbolic multilateration technologies are philosophically suited to the IVHS tasks. They provide the vehicle's position at the location where it is used -- remote from the vehicle.[4] However, some implementations of hyperbolic multilateration systems, such as those of Teletrac and METS/MobileVision[5], fall

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[4] Stand-alone vehicle location systems, such as GPS, require a second communications system to transmit the location information back to the central location where it is used.

[5] The reported 20 fixes per second capacity of the 2 MHz QuickTrack system utilized by Southwestern Bell Mobile Systems is even smaller.

far short of the dual capacity requirements of major metropolitan areas:

First, the maximum position fixing rates for both systems are between 35 and 100 position fixes per second, using 8 MHz throughout a given geographic market. Because they do not reuse spectrum, their position-fixing rate is fixed, regardless of the size of the metropolitan coverage area at issue. Using all the system's capacity of traffic monitoring barely satisfies the needs of a small metropolitan area (less than half a million population).

Second, if all of the narrowband 250 kHz forward-link bandwidth of these two systems were applied to data communications, the aggregate throughput would be about 60,000 bps.[6] This assumes no position-fixing whatsoever, and is lower than the minimum data requirements for IVHS in a moderately-sized market, as discussed earlier.

Moreover, narrowband data radios with this level of performance are only now becoming available, but at the very high cost (in relation to the target market's cost expectations) of about $2,000. This cost will likely inhibit rapid acceptance by the IVHS target market.

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[6] The forward-links were modeled as twenty 12.5 kHz-wide data channels capable of a user throughput of 5,000 bps, with a 60% overall packet-data protocol efficiency for the short-duration transmission data and radio-link protocols.